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Indian Standard

GUIDE FOR THE EVALUATION OF INSULATION SYSTEMS OF ELECTRICAL EQUIPMENT

PART 6 PERFORMANCE EVALUATION BASED ON SERVICE EXPERIENCE AND FUNCTIONAL TESTS

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GUIDE FOR THE EVALUATION OF INSULATION SYSTEMS OF ELECTRICAL EQUIPMENT

PART 6 PERFORMANCE EVALUATION BASED ON SERVICE EXPERIENCE AND FUNCTIONAL TESTS

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PART 6 PERFORMANCE EVALUATION BASED ON SERVICE EXPERIENCE AND FUNCTIONAL TESTS

0. FOREWORD

0.1 This Indian Standard (Part 6) was adopted by the Indian Standards Institution on 19 May 1986, after the draft finalized by the Electrical Insulation Systems Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard (Part 6) is one of the series of standards dealing with guidelines for the evaluation of insulation systems of electrical equipment. These guidelines include methods of identification and general principles of functional evaluation of insulation systems together with test procedures to evaluate the behaviour of systems under different factors of influence.

0.3 This standard (Part 6) deals with performance evaluation of insulation systems on the basis of service experience and functional tests. General guidance on evaluation, ageing, etc, are covered in Part 1 of this standard. Test procedures with respect to different factors of influence are covered in Part 2 to Part 7 of the standard.

0.4 Insulation systems in electrical equipment for technical and practical reasons are generally subjected to multiple influences at varying levels of stress. The interactions between these influences are very seldom known. It is partly for this reason that Part 1 warns that the practice of evaluating insulation systems on the basis of endurance figures for insulating materials is not valid. It is considered extremely difficult to model these influences on an insulating material without modelling the insulation system of the equipment itself.

0.5 There do exist simply stressed insulation systems where interactions are at a low level and where an estimation of service capability from endurance data for insulating materials may be acceptable. The acceptability of this approach must be determined by the Equipment Technical Committee.

0.6 Service experience is the ultimate evidence of the capability of an insulation system. For insulation systems which have operated for a sufficient time, service experience is the preferred basis for evaluation and identification. Also, this service experience, substantially expressed by and condensed into reference insulation systems, is the basis of any comparative functional test evaluation of insulation systems.

0.7 Service experience data of insulation systems in electrical equipment are available in many forms. Depending on the interests of the group in need of the data, for instance users, producers, insurance companies and others, the data may be largely statistical or technical in character. Without establishing rules, data gathering will not be uniform. It is the purpose of this to put forth some general ideas for establishing such rules for collection and evaluation of service experience data of insulation systems.

0.8 In the preparation of this standard considerable assistance has been derived from IEC Doc: 63 (Central Office) 19 'Performance evaluation of insulation systems based on service experience and functional test' issued by the International Electrotechnical Commission.

1. SCOPE

1.1 This standard (Part 6) gives guidance to equipment technical committees on the procedures to be adopted for evaluating the performance of insulation systems from service experience and from the results of functional tests.

2. GENERAL OUTLINE OF EVALUATION PROCEDURE

2.1 It is the responsibility of equipment technical committees to prepare specific procedures defining the evaluation and identification of insulation systems based on either service experience or the results of functional tests. These procedures should follow existing Indian Standards where appropriate and they should accomplish one or more of the following:

a) Specify how service experience data can be used for the evaluation of service-proven insulation systems.

b) Specify how a service-proven insulation system which has been evaluated can be used for comparative functional evaluation tests with a new insulation system.

c) Specify in detail how functional tests should be performed to obtain data for insulation systems evaluations.

d) Specify how the results of functional tests should be interpreted in insulation systems evaluations.

3. NATURE OF SERVICE EXPERIENCE DATA

3.1 General Remarks

3.1.1 Insulation systems have been evaluated on the basis of service experience ever since the beginnings of the electrotechnical industry.

Engineers use specific items of service experience related to the design task of the moment. More general service experience has been qualitative in character when expressed in generally accepted standards.

3.1.2 On the one hand, it is claimed that service experience or accepted tests are the basis for thermal evaluation of insulation. On the other hand, service experience is claimed when recognizing insulation systems on the basis of their composition from listed groups of materials for specific thermal classes. This is qualitative acceptance of worldwide application and experience over a long time with satisfactory economic life.

3.1.3 Although numerous standards call for service experience or accepted tests to be used in evaluating insulating materials and insulation systems, no clear rules are available on how this is to be done in specific cases.

3.1.4 It is recommended that equipment technical committees analyze how service experience has been used in the past within their specific fields of responsibility and how successful these methods, mostly qualitative judgements, have been. From these analyses, recommendations may be made for future practice and introduction of more quantitative methods.

3.2 Categories of Equipment

3.2.1 The categories listed below may be useful as an aid in selecting an appropriate evaluation procedure for a collection of service experience data and in choosing a reference insulation system for a comparative functional test.

a) Long life, large equipment — Few units, most or all used to determine service experience.

b) Long life, small equipment — Usually, but not always many units, poor knowledge of users data, statistical sampling may be used to determine service experience.

c) Short life, large equipment — Few units, generally all used to determine service experience.

d) Short life, small equipment —	Usually, but not always very many units, poor or no knowledge of users data, evaluation may be based on a statistically significant number of samples that were exposed to normal service conditions.

3.2.2 There may be other categories which will require the equipment technical committees to develop special rules for the evaluation of service experience data.

3.3 Service Experience Data

3.3.1 The service experience data should include all relevant service conditions to which the insulation system is exposed. Before service experience can be treated in a quantitative way it is necessary that data collection be restricted to closely similar systems employed in essentially identical functions. Although presentation of detailed data is desirable it must be recognized that presentation of precise numerical data will not be possible in the majority of practical cases.

It may be better in such cases to use all available information about service experience which provide a frank assessment of its positive aspects and limitations.

3.3.2 To establish the capability of a candidate insulation system, information about the following items should, if possible, be collected:

a) The kind deterioration observed in service and, if available, the nature of failures (treeing in cable, failure to ground in transformer, etc).

b) Service stresses on an insulation system.

   1) *System Design* — The actual voltage stress, mechanical (vibration and thermal expansion effects) and other stresses which the insulation system will experience are determined by the design.

   2) *Duty* — This includes the load cycling as well as standby periods.

   3) *Transients* — The actual transients to which the insulation system is exposed may be significant to its ageing. For example, sudden short-circuits near the equipment or out-of-phase switching can produce severe mechanical stresses in the insulation system. Also, over-voltages which occur in service may affect the life.

   4) *Environment* — The actual environment in which the insulation system has operated, needs to be considered.

- c) Maintenance of the insulation system during its life. Modification may be made to the insulation system in the form of replaced, changed or added components. In collection of service experience in awareness of the changes and their significance is necessary.
- d) Transportation, storage and installation.
- e) The performance data from service experience. They should be given in conformity with the cases dealt with in **6.2**.

3.4 Performance

3.4.1 Service performance gained directly from experience is generally not identical with the 'intended performance' or 'estimated performance' as given in Part 1 of this standard. Actual performance data have an absolute meaning; they are real figures of life of the insulation system, such as time to failure, time uneconomical failure rate, time of service without failure etc (*see* **6.2**).

3.5 Coding of Service Conditions

3.5.1 The technical committee should determine methods by which the actual service conditions can be identified. Methods given in Part 1 of this standard may be used.

4. FUNCTIONAL TEST DATA

4.1 Test data are generated according to test procedures based on Part 2 of of this standard.

4.2 Confidence in the estimated performance of an insulation system is dependent on how well the service conditions are modelled in the test procedures.

4.3 The performance values from functional tests should be given in conformity with **6.3**.

5. ESTABLISHING PROVEN PERFORMANCE

5.1 The main purpose of establishing proven performance of an insulation system from service experience data is to make possible its use, as a reference, in comparative evaluation of another insulation system.

5.2 The Equipment Technical Committee should establish rules for determining the performance of an insulation system. In establishing the rules, the Technical Committee should consider the effects of maintenance, particularly on long-life equipment. Service experience may be expressed in many ways (end of life, drop in performance, reliability, etc). If reliability is used to express service experience, change in failure rates may present much information. Such information permits consideration of economical serviceability as an end point criterion.

6. PERFORMANCE EVALUATION

6.1 General Remarks

6.1.1 To assess the overall capability of an insulation system, it is necessary to evaluate the system's performance under the ageing factors as described in **6.3**. There is, at present, no generally accepted technique which can be used to combine the results of different functional tests on separate groups of test objects into an overall evaluation of the capability of an insulation system.

6.1.2 While approved comparative functional tests may provide valuable insights into the performance of a new insulation system, it is important to remember that the ultimate criterion for comparison of insulation systems is their relative service performance. Equipment technical committees should recommend periodic review of the service performance of insulation systems which have been adopted as a result of comparative functional testing. Such a review will help to determine, if the test procedure is working as intended and will provide guidance for appropriate changes.

6.2 Proven Performance Values in Relation to Service Conditions

6.2.1 As previously stated, the Equipment Technical Committee should establish rules for qualifying an insulation system as having proven performance as shown by experience in the actual service conditions. These rules will be required for each specific type of equipment; the performance data must be proven to be comparable and may then be treated statistically as a self-consistent group. In some cases failures may not be representative of deterioration resulting from normal service but may be caused by errors in manufacture, damage due to transportation, poor storage, and adverse conditions, such as those caused by failures of other components. It may be necessary to give special treatment to this class of failures and not include them in the service experience records used to develop meaningful statistical data. Also, the term 'failure' may signify a condition other than the actual breakdown of the insulation (*see* **3**).

6.2.2 There are three typical cases of groups of service performance values, the most common being Group (b).

a) Performance data are all obtained from results of service failure as an end-point criterion.

b) Performance data are obtained partly from service failures and partly from 'service experience — without-failure'.

c) Performance data are all obtained from 'service experience — without failure'.

Examples of information obtainable from service experience are as follows:

a) Service hours of distinct pieces of equipment under defined conditions,

b) Numbers of pieces of equipment in operation for specific applications, and

c) Description of a reference insulation system with a record of service experience used by the equipment manufacturer.

6.2.3 Whenever sufficient data on service failures (or operation without failures) are available it is desirable to use statistical analysis techniques to qualify an insulation system for the particular application or to establish the performance of a reference system. This performance can be expressed in such terms as mean time of first failure, mean time to median failure, mean time between failure and others. Such a knowledge will allow comparisons to be made early in the service life of the systems. Techniques are currently being developed using Bayesian statistics to obtain estimates of failure parameters and might be considered, when applicable.

6.3 Interpretation of the Relationship Between Stress and Time-to-End-Point Obtained from Functional Tests

6.3.1 The results of accelerated ageing tests are useful in comparing the behaviour of two systems under these conditions of test, but care is needed in analyzing and interpreting these results to provide guidance on the actual performance in service. This is, in principle, a problem of extrapolating with acceptable confidence.

An evaluation in terms of the insulation system codes of Part 1 of this standard with quantified ranges of intended performance requires detailed evaluation rules. Statistical procedures for the estimation of confidence may be required.

6.3.2 An evaluation in terms of a statement 'at least as good as', on the other hand may be possible on the evidence that the investigated system's relationship between stress and time-to-end-point coincides with, or is better than that of the reference system in the whole region of test stresses. However, it should be reasonably certain that the corresponding curves do not intersect in the region encompassing test and service stresses.

6.3.3 As recognized in Part 1, it is desirable to make evaluations in absolute terms. However, this appears to be generally impossible at this time. In the present state of art of electrical insulation technology only comparative evaluations may be made. The idea of absolute evaluations may be easiest to approach with short-life small equipment, and most difficult with long-life large equipment where models and acceleration have to be used.

6.3.4 Equipment technical committees, when assessing the relationship between stress and time-to-end-point, should clearly note that the values of time, either within the test range or extrapolated, do not necessarily reflect the operating life of the equipment in absolute terms.